COMMERCIAL/INDUSTRIAL WASTE PLASTIC FEEDSTOCK PROCUREMENT AND SENSITIVITY ANALYSIS FOR A MIXED PLASTICS RECYCLING FACILITY

DECEMBER 1990

Environment
Environnement
Ontario

Commercial/industrial waste
plastic feedstock procurement
and sensitivity analysis for a
mixed plastics recycling facility /

ISBN 0-7729-7771-2

COMMERCIAL/INDUSTRIAL WASTE PLASTIC FEEDSTOCK PROCUREMENT AND SENSITIVITY ANALYSIS FOR A MIXED PLASTICS RECYCLING FACILITY

Report prepared by:
Sagres Metal & Plastics Ltd.
The Proctor & Redfern Group

Report prepared for:
Industrial Program Unit
Waste Management Branch
Ministry of the Environment

DECEMBER 1990

RECYCLABLE

Cette publication technique
n'est disponible qu'en anglais

PIBS 1339

DISCLAIMER

This report was prepared for the Ontario Ministry of the Environment as part of a ministry-funded project. The views and ideas expressed in this report are those of the author and do not necessarily reflect the views and policies of the Ministry of the Environment, nor does mention of trade names or commercial products constitute endorsement or recommendation for use.

ABSTRACT

The supply survey has established the existence of large quantities of plastic waste which are currently not being recycled. This material is generally unattractive to the plastic regrind industry because it consists of mixtures of resins or is contaminated. A large portion of this material is acceptable to the proposed facility.

Based upon the relatively small portion of all generators of plastic waste contacted, it is evident that there is enough available waste plastic from commercial and industrial sources to meet the requirements of several mixed waste plastic recycling machines.

An analysis of the cost of obtaining this material clearly shows that supply from large sources is economical at the target cost of 11 cents per kilogram (5 cents per pound). The .collection of plastic from small quantity sources is uneconomical.

It will not be economical to offer any but the largest generators any remuneration for material collected.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF APPENDICES

1.0 INTRODUCTION

1.1 Commercial/Industrial Solid Waste Recycling

Commercial/Industrial related solid waste is estimated to account for between 50 to 60% of the total solid waste stream in urban areas. This percentage would increase dramatically if all commercial/industrial solid waste was destined for public and private disposal facilities. Fortunately, it is estimated that the quantity of commercial/industrial solid waste recycled may be as high as 30%.

The variety of commercial/industrial solid waste produced is enormous. Most commercial/industrial solid waste are never seen at municipal disposal facilities. Mining, forest, and agricultural solid waste are obvious examples. Solid wastes from urban industry and commercial operations may not be disposed at municipal facilities for a number of reasons:

- they may be excluded by the municipality, (e.g. hazardous waste, sludges, liquid waste);
- they may be reprocessed internally, (e.g. paper mill broke, plastic trimmings);
- they may be sold or given to others to reprocess, or others may be paid for removal of waste (e.g. saleable by-products, salvageable transport and packaging material);
- they may be disposed at private, non-municipal waste disposal facilities;
- they may be disposed "internally", in whole or in part, (e.g. Ford, 3M's energy from waste facilities);

The commercial/industrial solid waste disposed at municipal facilities is therefore only a portion of all waste produced by the private sector. It must be waste acceptable to those facilities. In general, waste will only be disposed at municipal facilities if this is judged to be the lowest cost alternative from the options listed above. Consequently, tracing the path of commercial/industrial solid waste disposal is not an easy task.

Table 1.1

Potential Sources of Industrially Generated Plastic Waste and Scrap (1974)

Airlines and Airports
Automotive and Accessory Manufacturers
Battery Manufacturers
Blister Packagers
Canadian National Exhibition
Carpet Manufacturers
Car Wreckers and Shredders
Catering Companies
Computer Manufacturers and Major Users
Construction Companies
Compounders
Dairies
Electrical Goods Manufacturers
Extruders of Plastics, Fibers and Filaments
Food and Beverage Manufacturers & Distributors
Foam Manufacturers
Footwear and Shoe-Findings Manufacturers
Hardware and Construction Material Manufacturers
Hospitals
Importers and Distributors of Plastics Resins
Industrial Refuse Collectors
Injection and Compression Moulders
Laminators and Calendering Operations
Meat, Margarine, Shortening and Other Packers
Office and Copying Machine Manufacturers
Ontario Hospital Services Commission
Packaging Companies
Packaging Materials Manufacturers
Pharmaceutical, Drug and Cosmetic Manufacturers
Photographic Manufacturers and Processors
Plastics Machinery Manufacturers
Record and Tape Manufacturers
Resin Manufacturers, Processors and Reprocessors
Scrap Metal Dealers and Processors
Soap, Detergent and Household Goods Manufacturers
Specialty Paper and Board Manufacturers and Converters
Sports Arenas
Supermarket Companies
Telephone and Other Utilities
Thermoformers
Tire Manufacturers
TV and Radio Manufacturers
Universities (Catering)
Wire and Cable Manufacturers

(Source: F.T. Gerson Ltd., 1974)

The composition of commercial/industrial waste has many of the same categories as residential waste: plastic, paper/cardboard, glass, metal, organic waste and wood. However, there is a considerable difference in the waste composition between industries and commercial operations compared to households. In addition, commercial/industrial solid waste will vary from region to region depending upon the industrial base. These are two reasons why waste composition studies are readily available for municipal solid waste but generally absent for commercial/industrial solid waste.

1.2 Commercial/Industrial Plastic Waste and Scrap

In January, 1974, the Ministry of Industry and Tourism (MIT) and the Ministry of the Environment (MOE) commissioned a study entitled "Survey of Industrially Generated Plastic Waste and Scrap". A total of 44 "industrial" categories were identified as being potential sources of plastic waste and scrap (Table 1.1). Due to study limitations, an attempt was made to approach only the major potential sources of plastic waste and scrap from the 44 categories.

A total of 947 circular letters and questionnaires were mailed in the Province of Ontario of which 295 were returned corresponding to a 31% questionnaire response rate. One hundred and sixty one (161) responses were classified as "significant returns" and 134 responses were classified as "insignificant returns". The study only analyzed the significant returns and found that:

> "The current volume of industrial plastics waste and scrap generated in Ontario by the significant respondents to this survey amounted to 87 million pounds per annum. Of this total, 28.6 million pounds were recycled within respondents' organizations, while a further 21.4 million pounds were sold to reprocessors or scrap dealers, or transferred to other uses. The remaining 37 million pounds per annum of plastics waste and scrap were dumped, incinerated, turned over to refuse collectors or otherwise disposal of as solid waste" (F.T. Gerson Ltd., 1974).

These quantities were considered to represent only a part of the total weight of plastic waste and scrap generated by industry in Ontario. In addition, the study concluded that:

> "Almost none of the 37 million pounds of currently rejected plastics waste and scrap represents material which is sufficiently clean and homogeneous to be utilized by recovery methods now available in Ontario. New technology is required to make economic use of this waste (F.T. Gerson Ltd., 1974)."

During the fifteen years since this study was published, several changes have occurred which have an effect on scrap plastic generation, processing and disposal including:

- increased use in plastics by industrial manufacturers and commercial operations resulting in the generation of more plastic scrap;
- increased waste collection and disposal fees for waste generated by the commercial and industrial sectors;
- increased network of purchasers (i.e. brokers, manufacturers, etc.) of clean and homogeneous plastic scrap;
- increased number of commercial/industrial operators who have become willing to reduce waste disposal fees by using scrap plastic as part of feedstock if the end-product remains the same quality; or finding alternative methods to reduce disposal charges;
- increased number of technologies which are capable of using industrial plastic waste and scrap and/or post consumer (e.g. household) plastic as feedstock. The three main technological categories are: washing/upgrading technologies, separation technologies and mixed plastic recycling technologies. In addition, combinations of the above technologies may be found.

1.3 Objectives of the Study

The first objective of this study is to identify approximately 900 tonnes per year (990 tons per year) of plastic waste, suitable for a mixed plastic recycling facility, from commercial/industrial sources. One thousand tonnes represents twice the amount of plastic waste required to run the recycling technology two shifts per 260 working days annually. Other assumptions used in determining the 900 tonne minimum requirement include a shift length of 7 1/2 hours, continuous output of the machine rated at 200 kg (440 lbs) per hour and approximately a 10% level of rejection of incoming plastic waste.

Describing and evaluating methods to collect waste plastic from generators is the second objective. The final objective is to describe and evaluate several facility operating scenarios using information obtained on feedstock procurement, collection methods and facility establishment and operation cost figures.

The study findings will assist both the Ontario Ministry of the Environment (MOE) and Sagres Metal & Plastics Ltd. (Sagres) in their respective future plans. Both will benefit from the observations made on this "snapshot" picture of commercial/industrial waste plastic generators and be able to compare them with other related research. In addition, the availability and suitability of commercial/industrial waste plastic for a mixed plastics recycling facility is proven and provides the MOE Industrial Program Unit with supported evidence as it further investigates methods to recycle commercial/industrial waste plastic. This information is also vital to Sagres as it proves that waste plastic can be obtained from sources other than the household.

1.4 Scope of the Investigation

The scope of the investigation was limited to sources of commercial/industrial plastic waste. These sources were targeted in part because the availability of residential plastic was dependent upon municipal initiatives over which the processor had little control, and in part because information on availability of plastics from municipal blue box recycling programs was being generated in

Ottawa and Mississauga. This does not however represent a commitment on the part of Sagres to source its supply solely from commercial/industrial waste plastic generators.

The Regional Municipality of Peel was considered an appropriate location for a conceptual facility, thus the companies selected to be contacted, for the most part, were located between the City of North York and the City of Burlington. Also, it was necessary that companies be located as close as possible to series 400 highways (e.g. 401, 427, etc.).

The plastic obtained must be an appropriate mix of resins. Further, because of the relatively low grade use of the proposed end products, that is as a more durable substitute for wood, the material must be obtained at a price substantially below the prevailing price for waste plastic obtained for regrind. Also the waste plastic must be obtained at cost to collect which permits production of a product at an acceptable price.

1.5 Overview of Plastic Resins and Uses

About 80% of the plastics produced in Canada are derived from 7 resin types: polyethylene (PE), polypropylene (PP), polystyrene (PS), acrylonitrile butadiene styrene (ABS), polyvinyl chloride (PVC), polyurethane, and polyester (Table 1.2). In addition, multi-layer plastics, made from combining in layers various common resins, and engineering plastics, a "new breed" of high performance plastics, are capturing a percentage of the market. The 7 resin types, sometimes referred to as "family" names, are processed into a wide range of plastics with varying properties (e.g. colourability, optical clarity, flexibility, durability) particular to the intended use (Table 1.2).

The majority of plastics in use today can be grouped under one of two headings: thermoplastics or thermosets. Thermoplastics are single chain polymers (long chain molecules) which harden when cooled but soften at varying temperatures according to resin type. Consequently, thermoplastics are capable of being re-moulded. Thermosets are cross linked polymer chains which harden permanently with chemicals or heat and cannot be re-melted without degrading polymer linkages. Thermoplastics represent between 80 and 85% of the plastics in use and have become the target group for plastics recycling.

Other names characteristic of plastic usage include: rigid (e.g. bottles and containers), films or flexible (e.g. packaging, bags), durable (e.g. long life purposes), high impact (e.g. long life or aggressive uses), and throw away (e.g. one time use). The range and mixture of properties and characteristics are why plastic or partial plastic products are used daily in Canada. Plastics are found in the home and office, grocery and department stores, various modes of transportation, construction and industry, agriculture, and leisure and athletic activities.

Table 1.2
Resin Types, Processed Plastics and Common Uses

Resin Type	Common Processed Plastics	Common Uses
Polyethylene (PE)	High Density Polyethylene (HDPE)	- rigid containers including detergent, dairy and cosmetic bottles; motor oil bottles, windshield fluid bottles, - durable uses including automotive parts, toys, buckets, drums, pipes, insulation for power cables,
	Low Density Polyethylene (LDPE)	- film or flexible applications including grocery sacks, dry cleaning bags, food wrapping, garbage bags, industrial linings, paperboard coatings,
Polypropylene (PP)	PP	- durable uses including automotive battery cases, washing machine agitators, furniture, conduit, fibres for carpets, - film or flexible applications including snack food packaging, cigarette packaging, diapers, - rigid applications including coat hangers, cutlery,
Polystyrene (PS)	"high-impact" PS	- rigid items including disposable razors, cutlery, prescription and vitamin bottles, coffee cups,
	"semi-rigid" PS	- pliable items including container lids, dairy tubs, butter pats,
	"oriented or crystal" PS	- cellophane-like films including carry out containers, cookie package trays,
	"expanded, blown or foamed" PS (trademark name Styrofoam)	- durable uses including refrigerator linings, thermal insulation board, - rigid items including coffee cups, food trays, plates, hamburger "clamshells", - durable protective packaging including egg cartons, shipping materials,
Acrylonitrile Butadiene Styrene (ABS)	ABS	- durable uses including pipes, housings for telephones, hairdryers, radios and business machines; brief cases, sports helmets, toys, automotive parts,
Polyvinyl Chloride (PVC)	"Vinyl"	- durable uses including house siding, pipes, floortiles, records, waterproof footwear and garments, camping gear, air mattresses, credit cards, - rigid items including salad and vegetable oil bottles, mineral water bottles, - film or flexible applications including meat wraps, bottle cap liners, can coatings,
	Polyvinylidene Chloride (PVDC) (trade name "Saran")	- film or flexible applications including shrink wrap, "barrier" packaging,
	Ethylene Vinyl Acetate (EVA)	- film or flexible applications including "barrier" packaging,

Table 1.2
Resin Types, Processed Plastics and Common Uses

Resin Type	Common Processed Plastics	Common Uses
Polyurethane	"flexible foam"	- durable uses including cushioning for aircraft seats, car seats and furniture,
	"rigid foam"	- durable uses including insulation for refrigerators, building walls, cold storage buildings,
	"elastomer"	- durable uses including ski boots, car bumpers, tractor tires,
Polyester	"fibre glass"	- durable uses, when combined with glass fibre, including boats, car bodies, petrochemical tanks, building panels,
	"soft and flexible"	- film and flexible applications including sterilizable pouches, garments
	Polyethylene Terephthalate (PET)	- rigid containers including soft drink bottles, condiment bottles, microwaveable trays
Multi-Layer Plastics	"barrier" (e.g. PP, PVDC, EVA, LDPE, PS)	- rigid containers including ketchup and condiment bottles, dairy bottles, - film or flexible applications including specialized food packaging
Engineering Plastics	Nylon	- durable items including gear and door hinges, appliances parts, tennis racquet strings, zippers,
	Acetal	- durable items including industrial bearings and wheels,
	Acrylics	- durable items including outdoor signs, safety glass, skylights, automotive tail lights,
	Fluoroplastics	- durable uses including non-stick coatings for frying pans, linings for petrochemcial tanks, microwaveable dishes, oven dishes,

(Sources: Compiled from SPI Canada, No date; Brewer, 1988)

v4:a:\mar-t1-2.xls

2.0 COMMERCIAL/INDUSTRIAL WASTE PLASTIC FEEDSTOCK PROCUREMENT

The recycling technology process can accept a mix of thermoplastic resins commonly discarded by commercial/industrial establishments. These are:

- polyethylene (PE),
- polypropylene (PP),
- polystyrene (PS),
- polyvinyl chloride (PVC).

Some restrictions on the percent by weight of individual resins in the mix are advised. PVC and family member polyninylidene chloride (PVDC) should not constitute more than 10% by weight unless a thermal stabilizer is added to the mixture to eliminate the risk of problem emissions (e.g. hydrochloric acid). Non impact (e.g. oriented or crystal) and expanded PS should be limited to 10% by weight. The recycling technology is also capable of accommodating between 20 and 40% contamination by other materials commonly present in the commercial/industrial solid waste stream including glass, paper, dirt, metal and thermosets. Recent experiments with feedstock have indicated that the list of contaminants may be further expanded to include items such as sawdust and ash.

The mix used affects both operating parameters of the process operation cost, and final product quality. While substantial variations can be accepted, and tolerances are not generally critical, the mix with a demonstrated effective performance is roughly: 30% HDPE, 30% LDPE, 30% PP and 10% other thermoplastic (PS, PVC, etc). Recent experiments have demonstrated that a single plastic resin feed is possible with appropriate additives. Further, barrier packaging may be run with little preparation provided the individual layers are known.

2.1 Data Collection Methods and Limitations

Data collection for this study occurred in two parallel phases identified as:

- Phase One: Compile list of Commercial/Industrial Plastic Waste Generating Categories.

  Assistance in compiling a list of commercial/industrial plastic waste generating categories and individual companies was obtained from the Ontario Waste Exchange; waste reduction/recycling coordinators in the municipalities of Metropolitan Toronto, Peel, Halton and Hamilton-Wentworth; the Society of Plastics Industries of Canada (SPI); and MOE District Offices in Hamilton and Toronto. Additional information was obtained through non-structured telephone interviews, written contact and published and unpublished documents.

- Phase Two: Survey of Commercial/Industrial Waste Plastic Generators

  Data collection involved the design and implementation of a telephone survey and appropriate site visits.

2.1.1 Study Design

To obtain information on waste plastic composition and quantity, consideration was given to distributing a survey to selected commercial/industrial establishments. A second consideration in the study design was how to solicit the necessary information. Three options existed:

a) mail out a package containing a cover letter, survey, and a stamped, self-addressed return envelope
b) telephone each establishment and administer a survey
c) visit each establishment

Option b) was selected as the predominant mechanism to obtain information. Some establishments were visited (option c) because their plastic waste composition and quantity was significantly large, completely unknown, extremely contaminated or an unusual mixture. Option a), a questionnaire distributed by mail, was deemed inappropriate due to the minimal length (i.e. eleven weeks) of this study and the historical low response rate unless an aggressive questionnaire follow up campaign is instituted.

The F.T. Gerson Ltd. (1974) study served as a basis for initially selecting thirty four categories (refer to Table 1.1). The selection of the thirty four categories was based on the following considerations:

- being as consistent as possible with selecting categories that have been previously identified in plastic waste inventories,
- selecting categories that included one or two known large generators of waste plastic.

A list of establishments was compiled in two parts using material supplied from the Regional Municipality of Halton, the Municipality of Metropolitan Toronto, the Ontario Waste Exchange, Ontario Manufacturers 16th Edition (Scott's Directories) and telephone directories for Metropolitan Toronto and vicinity, and Halton and Peel Regions.

Part one involved selecting and telephoning either two or three establishments per category in an attempt to determine whether or not waste plastic was currently being disposed by that category. Part two involved contacting more establishments within the promising categories. A total of 175 telephone calls were placed of which 158 responded in some manner to the telephone survey. The number of categories were consequently reduced to eleven generic categories and one "other" category as follows:

- Automotive and Accessory Manufacturers
- Extruders and Moulders
- Food, Dairy and Beverage (packagers, bottlers and distributors)
- Resin Manufacturers and Compounders

- Electrical, Wire and Cable Manufacturers
- Packaging Materials Manufacturers
- Sundry Plastics Manufacturers
- Laminators and Calendering Operations
- Automotive Wreckers and Scrap Metal Processors
- Automotive Service Stations
- Supermarkets, Shopping Malls and Warehouses
- Miscellaneous

2.1.2 Study Limitations and Confidentiality

Waste plastic composition was known by approximately 70% of those surveyed, however quantities were much harder to obtain from plant managers or other key contacts. Consequently many respondents were classified as "various" composition and quantity. Several telephone participants suggested it would be a difficult job to obtain an accurate or credible figure and, in their opinion, not worth the effort required to search through company files.

All company information received as part of this study is treated confidentially to protect those companies that requested anonymity. Furthermore, these companies have been single-out as potential waste plastic sources for Sagres.

2.2 Survey Interpretation, Discussion and Findings

This section documents and discusses survey respondents' plastic waste composition and quantity by resin type, resin processed or other attribute (Table 2.1) and commercial/industrial source (Table 2.2). Both tables have four columns identified as:

> **Predominately Rigids or Films** - refers to a generic plastics classification (characteristic) scheme; rigids (R) include various containers, car parts, etc. and films (F) include various packaging and bags.

Total Reported (kgs and lbs) - refers to the amount of waste plastic reported by the respondent or estimated by the Study Team based on the respondents description of quantity and composition.

Total Unavailable (kgs and lbs) - refers only to the reported quantity of material that is currently being purchased or accepted by other firms or recycled at source.

Total Available (kgs and lbs) - refers to the amount of waste plastic that is currently reported to be available for a mixed plastics recycling facility if the material is in fact acceptable.

2.2.1 Availability of Waste Plastic By Resin Or Other Attribute

Thirteen resin types, resins processed or resin attributes were identified by respondents. This variation was the result of some respondents' inability to identify specific resins being discarded. Most respondents were able to distinguish between rigids and films, however some resins are used for both rigid and film purposes (e.g. PP, HDPE, LDPE). This prompted the use of the word "predominately" in the description. For the purpose of this study, the imprecise classification, as seen on Table 2.1, is sufficient.

The telephone survey identified a total of 10,605 tonnes (11,690 tons) of waste plastic of which 4,979 tonnes (5,489 tons) are considered available as feedstock for a mixed plastics recycling facility. The total available does not include waste plastic that is currently being purchased but which would be available if an appropriate price were offered. HDPE, PP and EVA accounted for 91% of the waste plastic identified.

Over 922 tonnes of HDPE were identified from 23 sources contacted of which 919 tonnes are considered available. Automotive service stations comprised 17 of the 23 sources, however this category contributed less than 1% of the total HDPE. Rigid HDPE was the most common characteristic identified. Containers and bottles were determined to be the predominant former use. Contamination varied from paper and foil labels to different residues still remaining within the bottles and containers. Many container and bottle distributors now use a plastic

Table 2.1
Total By Resin Type or Other Attribute

Resin	Predominately Rigids or Films	# of Sources Identified	Total Reported kgs	Total Reported lbs	Total Unavailable (a) kgs	Total Unavailable (a) lbs	Total Available kgs	Total Available lbs
High density polyethylene	R	23	922,357	2,033,460	2,948	6,500	919,409	2,026,960 (b)
Low density polyethylene	F	11	66,632	146,900	27,170	59,900	39,462	87,000
Polyethylene	F	2	45,178	99,600	38,102	84,000	7,076	15,600
Polypropylene	R	7	8,196,643	18,070,600	5,467,574	12,054,000	2,729,070	6,016,600 (c)
Mixed thermoplastics	F	9	180,574	398,100	1,293	2,850	179,281	395,250
Polyvinyl chloride	R	6	200,668	442,400	66,088	145,700	134,580	296,700
Ethylene vinyl acetate	F	4	528,568	1,165,300		-	528,568	1,165,300
Polyvinylidene chloride	F	4	179,304	395,300		-	179,304	395,300
Mixed polyester	F	1	27,215	60,000		-	27,215	60,000
Mixed laminates	F	1	3,130	6,900		-	3,130	6,900
Polystyrene	R	3	14,515	32,000		-	14,515	32,000
Thermosets	R	1	217,723	480,000		-	217,723	480,000
Miscellaneous plastics	F	3	22,915	50,520	22,680	50,000	236	520
TOTALS		71 (d)	10,605,424 (10,605 tonnes)	23,381,080 (11,690 tons)	5,625,854 (5,626 tonnes)	12,402,950 (6,201 tons)	4,979,570 (4,979 tonnes)	10,978,130 (5,489 tons)

(a) only includes quantities provided during telephone survey. Several respondents would not identify quantities currently being recycled at source or plastic waste currently being collected.

(b) estimated amount available will not be confirmed until July, 1989.

(c) estimated amount available will not be confirmed until June, 1989.

(d) several companies identified more than one plastic resin being discarded.

v4:c:\excel\mar-t2-1.xls

Table 2.2
Total Plastics By Commercial/Industrial Sources

Source Industry	Predominately Rigids or Films	# of Sources Identified	Total Reported kgs	Total Reported lbs	Total Unavailable (a) kgs	Total Unavailable (a) lbs	Total Available kgs	Total Available lbs
Automotive & Accessories	R	3	50,076	110,400	35,924	79,200	14,152	31,200
Extruders & Moulders	R	2	68,039	150,000	38,102	84,000	29,937	66,000
Food, Dairy & Beverage	F	8	108,998	240,300	1,293	2,850	107,705	237,450
Resin Manufacturers & Compounders	-	0	-	-		-		-
Electrical, Wire & Cable	R	2	217,723	480,000			217,723	480,000
Packaging Materials	F	8	788,974	1,739,400	75,477	166,400	713,497	1,573,000
Sundry Plastics	R	5	68,946	152,000	5,897	13,000	63,049	139,000
Laminators & Calendering	F	4	5,579	12,300	3,402	7,500	2,177	4,800
Automotive Wreckers & Scrap Metal	R	4	8,187,300	18,050,000	5,465,760	12,050,000	2,721,540	6,000,000 (c)
Automotive Service Stations	R	17	3,701	8,160			3,701	8,160
Supermarkets, Shopping Malls & Warehouses	F	2	113,398	250,000			113,398	250,000
Miscellaneous	R	10	992,691	2,188,520			992,691	2,188,520 (b)
TOTALS		65	10,605,424 (10,605 tonnes)	23,381,080 (11,690 tons)	5,625,854 (5,626 tonnes)	12,402,950 (6,201 tons)	4,979,570 (4,979 tonnes)	10,978,130 (5,489 tons)

(a) only includes quantities provided during telephone survey. Several respondents would not identify quantities currently being recycled at source or plastic waste currently being collected.
(b) estimated amount available will not be confirmed until July, 1989.
(c) estimated amount available will not be confirmed until June, 1989.

v4:c:\excel\mar-t2-2.xls

"sleeve" label for product identification purposes. Consequently a slight reduction in the contamination level may result as plastic labels would be an addition to the feedstock rather than a contaminant.

Seven sources of rigid PP were identified contributing over 8,196 tonnes to the total reported. In addition, one source of film PP may appear shortly. Automotive battery recycling accounted for virtually all the identified PP. The largest volume of PP is currently being sold in the United States after an extensive washing and upgrading process. The second largest source can not be confirmed until June 1989, however it is expected that the amount of contaminated PP available will be approximately 2,700 tonnes annually. Contamination levels can not be further identified at this time.

EVA was identified as the most frequently used layer in barrier packaging found at four sources and accounted for more than 525 tonnes annually. Clean EVA scrap was found at one source, however the remaining sources were contaminated with blood residue as a result of various meat packing operations.

Many respondents identified that their waste plastic was currently recycled at source because it is both clean and homogeneous. Waste plastic available for recycling at source usually resulted from substandard products being produced during equipment start up and shut down or cut outs from moulds. Several firms have been recycling their own plastic scrap for decades.

PE and PP account for the largest quantity of waste plastic currently unavailable due to an existing market. Clean PVC and LDPE were also identified as having a purchaser. Firms have generally struck informal collection and payment arrangements with a contractor. Level of service, convenience and ease to the company and payment for separated waste plastic appear to be the main concerns voiced by the respondents. Contamination levels and quantity generated appear to be the two dominant factors in determining whether or not waste plastic will be purchased or accepted by a recycling firm.

Thermosets is the only resin category identified in the survey that would not be considered worthwhile to further pursue. In addition, 3 of the 6 PVC sources represent waste plastic that is contaminated too heavily. This quantity represents less than 5% of total plastic waste available, therefore its exclusion will not effect the quantity available. As discussed previously, several resins or attributes are considered more desirable in the feedstock therefore total available "preferred" waste plastic by resin type or other attribute is identified in Table 2.3.

Table 2.3
Preferred Waste Plastic by Resin Type or Other Attribute

Resin Type or Other Attribute	kgs	lbs
HDPE	919,409	2,026,960
LDPE	39,462	87,000
PE	7,076	15,600
PP	2,729,070	6,016,600
Thermoplastics	179,281	395,250
EVA	528,568	1,165,300
PVDC	179,304	395,300
TOTAL	4,582,170	10,102,010

Based on the waste plastic quantity reported by survey respondents, a total of 4,582 tonnes (5,051 tons) of waste plastic are available for a mixed plastics recycling facility.

2.2.2 Availability of Waste Plastic by Commercial/Industrial Source

Eleven source industry categories and one other category were identified as potential suppliers of waste plastic for a mixed plastics recycling facility (Table 2.2). Within the 12 categories, a total of 65 companies or establishments reported waste plastic as a component of its commercial/industrial process. Findings specific to the individual categories are discussed in this section. The following general points, interpreted from the survey discussion, serve as an appropriate introduction to assist with understanding the individual categories and securing potential sources of waste plastic:

- Most companies do not know precisely what materials are discarded as part of their operation. Even more difficult is determining quantities of individual materials. Waste plastics served as a prime example of this inability. An effort was made to speak to the person responsible for production and waste disposal, however, it is quite possible that the person responding to the survey questions was perhaps not the most knowledgeable in the company/establishments waste disposal practices.

- Plastics waste generation is usually not consistent throughout the year, even within an identified category. Reasons for the inconsistencies are generally associated with production which is often inherently seasonal.

- Both large and small waste plastic generators were identified in the survey. Waste plastic generation ranged from one or two kilograms per day to over 1,500 kilograms. Other trends noted include some large quantities but occasional generation and smaller but consistent quantities with some modest seasonal variation.

- Several companies have been engaged in plastic waste reuse, reduction, recycling and recovery for years. The F.T. Gerson (1974) study identified similar findings for some industrial categories. Several companies contacted have found methods to deal with waste plastic only in the last

year. Increased disposal fees, environmental "awareness", and corporate image were often cited as reasons why effort was made to solve disposal problems.

- Many generators of waste plastic, primarily clean and homogeneous, indicated that they can and do sell the material regularly. However most also indicated that they are always open to new bidders or innovative approaches to handling existing material. Sources that generate more than one type of waste plastic suggested that a firm willing to accept all generated waste plastic would be viewed favourably.

- It was commonly found that where waste plastics are currently being purchased, the buyer approached the generator. A few survey respondents suggested that other firms have recently approached them concerning waste plastic generation. Some respondents wanted to know if other commercial/industrial solid waste such as old corrugated cardboard, ferrous metal, and office paper could be included with the waste plastic.

- In general, most generators of waste plastic are not out looking for opportunities to sell and several respondents were willing to provide the material free of charge. However, generators commonly asked "what's in it for me?" Disposal cost savings were often not considered a large enough incentive to separate waste plastic from the solid waste stream. Concern was often expressed about the reaction from employees if asked to do extra work. Many sources are hoping for some payment, but if the service provided to them is convenient and consistent, many would accept free removal.

- Waste plastic storage was not commonly cited as an issue. Notable exceptions included service stations. Solid waste is generally not stored at most sites longer than a week, however some respondents would be willing to store waste plastic for longer periods if required. Waste plastic generated by meat packing operations must be cleared weekly in the summer.

Automotive and Accessory Manufacturers

Seven automotive and accessory manufacturers were surveyed of which 3 were confirmed as sources of predominately rigid waste plastic. PVC and PE were the dominant resins found however the PVC was currently being purchased bi-weekly. The remaining PVC was coated with paint or metal trim.

The source of PE was estimated from one section of the manufacturing plant only, therefore a detailed survey may identify larger quantities. One source had a grinder on site and was capable of using the clean waste plastic. Over 70% of the total waste plastic reported was currently recycled at source or purchased/accepted by recycling firms.

Extruders and Moulders

Moulders and extruders were identified by F.T. Gerson Ltd. (1974) as being traditionally good material handlers, "including segregation of grades, types and colours of reground material; or closed loop regrinding and reprocessing of gates, spues, runners, trim and rejects." This category trait was confirmed in the current survey as several respondents made comments on the in-house recycling capabilities of the entire industry. Fifty-six percent (56%) of the plastic waste identified was currently being recycled at source.

Notable exceptions included an available source of mixed polyester and a small amount of thermoplastics as a result of spillage when changing moulds and morning start-up. This firm suggested that due to the number of different resins dealt with, it would not be worthwhile to recycle the individual resins internally. Clean PE identified at one source was currently baled and sold as part of a long term market commitment.

Food, Dairy and Beverage (packagers, bottlers and distributors)

The food, dairy and beverage industry, from packagers and bottlers to distributors of goods, provided a diverse group of resins, predominately films, including LDPE, PVC, EVA, PVDC, various laminates and miscellaneous thermoplastics. Waste plastic quality varied from clean and homogeneous to blood residue contamination. Waste plastic quantity ranged from 10 to 680 kilograms per week.

Recycling at source is currently not practiced although most would be willing to separate waste plastic from other solid waste (e.g. old corrugated cardboard, mixed paper) if it were made convenient. One company representative had been separating LDPE waste plastic voluntarily for the past year as a result of the corrugated cardboard ban in the Regional Municipality of Halton.

Due to various resin types, different levels of contamination, an inconsistent supply, and potentially small quantities this industrial category has traditionally not been viewed as an ideal source for current recycling efforts.

Resin Manufacturers and Compounders

No waste plastic was identified from this category. Similar to extruders and moulders, materials' handling controls are an essential part of a resin manufacturer or compounder's operation. In addition, identifying the manufacturing plant from the distribution/sales office was a difficult task due to the incomplete company activity description often provided in telephone directories and other sources. This accounted for two incomplete telephone surveys.

Electrical, Wire and Cable Manufacturers

Six electrical, wire and cable manufacturers were contacted resulting in one source of cross-linked PE (thermoset), approximately 215 tonnes annually, and one source with an unidentified quantity to be confirmed at a later date. One company representative suggested that large quantities of waste plastic would probably be found at select companies only, with many of these companies situated in the Regional Municipality of Hamilton-Wentworth (City of Hamilton).

Packaging Materials Manufacturers

Packaging materials manufacturers are the third largest source of available waste plastic. Waste plastic identified was predominately films with one or two exceptions. Processed plastics identified included: HDPE, LDPE, EVA, PVDC, PP, PS, PVC and barrier packaging. Quantities ranged from less than a kilogram up to 13,090 kilograms (28,850 lbs) per week.

Waste plastic was found to be usually clean and sometimes homogeneous, depending on the number of plastics packages produced. Although the barrier packaging identified during the survey was clean, many recycling firms view this material as inherently contaminated due to the various layers of plastic which can not be economically separated with today's plastic recovery technologies.

Only 10% of the waste plastic identified was considered unavailable as it was currently purchased by different recycling firms. One firm mentioned that two or more waste plastics were being generated on the premises however the recycling firm was only removing and paying for one material. This company suggested that a firm who would accept all waste plastic would be favoured. This trend was consistent with several other generators of two or more waste plastics where a full recycling service was not being provided.

Sundry Plastics Manufacturers

Sundry plastics manufacturers (e.g. toy manufacturers, garden hoses, plastic strapping, etc.) comprise those companies that did not clearly fall into one of the above categories based on a discussion with company officials. Waste plastic found included HDPE, PVC and thermoplastics, although the HDPE was currently being purchased. The PVC was reinforced with nylon, an engineering plastic, therefore its inclusion into the feedstock is not preferred.

Similar to extruders, compounders, and resin manufacturers, many companies contacted recycled at source and have been doing so for many years. Those who did not recycle at source were generally willing to separate waste plastic, although some type of incentive to do so was often mentioned.

Laminators and Calendering Operations

Small quantities of waste plastic were identified from laminators and calendering operations with over 60% of the material currently recycled at source. LDPE and PP were the common resins identified. A market currently existed for the LDPE from one source.

Automotive Wreckers and Scrap Metal Processors

Rigid PP from battery recycling operations dominated the waste plastic identified in this category. As mentioned previously, the largest volume of PP is currently sold in the United States after considerable washing and upgrading. Almost 70% of waste plastic identified was currently being purchased although this percentage is definitely skewed by the large single source. Another large source of PP will be confirmed in June 1989. A source of PP was also identified well outside of the Study Area however transportation costs may feasible if quantity shipped is large.

Sundry Plastics Manufacturers

Sundry plastics manufacturers (e.g. toy manufacturers, garden hoses, plastic strapping, etc.) comprise those companies that did not clearly fall into one of the above categories based on a discussion with company officials. Waste plastic found included HDPE, PVC and thermoplastics, although the HDPE was currently being purchased. The PVC was reinforced with nylon, an engineering plastic, therefore its inclusion into the feedstock is not preferred.

Similar to extruders, compounders, and resin manufacturers, many companies contacted recycled at source and have been doing so for many years. Those who did not recycle at source were generally willing to separate waste plastic, although some type of incentive to do so was often mentioned.

Laminators and Calendering Operations

Small quantities of waste plastic were identified from laminators and calendering operations with over 60% of the material currently recycled at source. LDPE and PP were the common resins identified. A market currently existed for the LDPE from one source.

Automotive Wreckers and Scrap Metal Processors

Rigid PP from battery recycling operations dominated the waste plastic identified in this category. As mentioned previously, the largest volume of PP is currently sold in the United States after considerable washing and upgrading. Almost 70% of waste plastic identified was currently being purchased although this percentage is definitely skewed by the large single source. Another large source of PP will be confirmed in June 1989. A source of PP was also identified well outside of the Study Area however transportation costs may feasible if quantity shipped is large.

Miscellaneous

Similar to sundry plastics manufacturers, a miscellaneous category was established to include a variety of plastic waste generators or handlers. Waste plastic identified included HDPE, LDPE, PVC, PP and thermoplastics. One firm identified it will be generating approximately 900 tonnes of contaminated HDPE annually. Further confirmation and contamination levels will not be available until July 1989.

As expected from a miscellaneous category, comments varied as to the quantity of waste plastic generated, contamination levels, storage requirements, accepting/purchasing waste plastic, etc.

2.3 Waste Plastic Collection Analysis

2.3.1 Methods of Collection

Waste plastic materials that are not currently recycled are mixed with other wastes and taken away by haulers to disposal facilities. The generator of the wastes pays the cost of removal and hauling fees.

Generators of mixed, contaminated waste plastic that could be recycled by the proposed plant would generally require the prospect of decreased costs to motivate them to separate plastic for recycling. However the cost of this separation and the separate hauling of plastic and other waste to two different destinations would cost more for in the case of most smaller generators. That is, the savings in tipping fees from recycling the plastic will not offset the increased cost of hauling. This is particularly true for the relatively bulky plastic materials.

For this reason, the user of the plastic waste will have to bear part or all of the cost of removal of the plastic material. This could be done by:

- providing a free removal service
- paying for material accepted at the plastic recycling facility

The free removal service could be performed by vehicles owned and operated by the recycler, or by vehicles operating under contract. Material delivered for payment could be delivered by the generator, or could be collected and delivered by private haulers (eg. waste haulers). There are precedents for each of these approaches in the collection of corrugated cardboard for recycling.

2.3.2 Cost Analysis

A few relatively large sources of plastic waste could be identified, from which the collection cost per kilogram would be relatively low. For these generators it would be economical to install a baler for predominantly film plastic or to use an existing baler currently baling cardboard, and collect the baled plastic on a flatbed truck.

An analysis of the cost of collecting from these sources is shown in Tables 2.4 a & b. The shaded part of Table 2.4 b represents loads smaller than one bale. It is also unlikely that a load of baled plastics could be picked up as frequently as every fifteen minutes, all day long. It would be feasible for a flatbed truck to collect two loads per day of about five tonnes each if average loads are two bales or more. It should be noted that such a rate of collection would meet the total requirements of three machines operating at full capacity, seven days per week. Film plastics would represent only about one third of this feed.

This indicates that the least cost approach would probably be to contract for collection of baled plastic. The truck would need to be hired on one or two days per week, or as required. It can be seen from this table that the cost of collection would range between about 4 and 10 cents per kilogram (2 and 5 cents per pound). This cost of collection is low enough that some payment would be possible to the larger plastic waste generators, in addition to providing free pick up.

For rigid plastics that are not amenable to baling, if the quantity is large, it may be economical to install a small grinder and move the ground plastic in Gaylords or other containers. This would not be attractive to the purchaser unless some assurance of the composition could be given. More likely, the material would be sent loose and unground, or collected in a compacting vehicle which allows the materials collected to be roughly sorted and classified and checked for unacceptable contaminants before use.

There are a considerable number of generators for which plastic is a significant portion of their waste, particularly if measured by volume, by which generate relatively small total quantities, much less than would justify a baler or other volume reduction approach.

An approach to collection from these smaller sources would require consideration of the following factors:

- size, number and type of collection vehicles to use,
- criteria for selection of sources,
- specification of material and quality control,
- terms of collection, ie payment, frequency,
- net cost for collected material

Several options were considered. The need for compaction or densification is evident from the very low density of most uncompacted plastics waste. Conventional densification using packer vehicles is a demonstrated and readily available approach. Rear loading packers were deemed to be preferable to front loading for the following reasons:

- lower initial investment - less expensive vehicle; dumpster type containers not required
- quality control - manual loading means material can be checked at source with unacceptable material not being brought to the processing plant
- potentially smaller quantities might be picked up

Table 2.4a
Bales On A Flat Bed Truck
Collection Analysis

Flat Bed Truck and Driver

Cost per year	$95,000
Cost per day	$380/day

Daily Productivity Versus Cost

		Cost of Collection		
		Per Tonne	Per Kg.	Per Pound
One Load Per Day	3.0 T/load	$127	$0.127	$0.058
	4.0 T/load	$95	$0.095	$0.043
	5.0 T/load	$76	$0.076	$0.035
Two Loads Per Day	3.0 T/load	$63	$0.063	$0.029
	4.0 T/load	$48	$0.048	$0.022
	5.0 T/load	$38	$0.038	$0.017

Table 2.4b
Bales On A Flat Bed Truck
Loading Time And Weight Per Stop

Available Loading Time

Loads Per Day	One	Two
Daily productive time	450 minutes	450 minutes
Travel/unloading time	50 minutes	100 minutes
Net route and loading time	400 minutes	350 minutes

Average Weight Per Stop

	Time Per Stop	15 minutes		30 minutes		45 minutes		60 minutes	
	One Load	26 stops		13 stops		8 stops		6 stops	
	Two Loads	23 stops		11 stops		7 stops		5 stops	
Loads Per Day	Tonnes Per Day	Weight Per Stop							
		Kg.	lbs.	Kg.	lbs.	Kg.	lbs.	Kg.	lbs.
1	3.0 T/day	115	254	231	508	375	825	500	1100
1	4.0 T/day	154	338	308	677	500	1100	667	1467
1	5.0 T/day	192	423	385	846	625	1375	833	1833
2	6.0 T/day	261	574	545	1200	857	1886	1200	2640
2	8.0 T/day	348	765	727	1600	1143	2514	1600	3520
2	10.0 T/day	435	957	909	2000	1429	3143	2000	4400

Shaded area deemed unfeasible due to cost, rate of pickup

Experience with collection of old corrugated cardboard from diverse sources confirms the above expectations. A number of companies perform such collections with rear loading packers, with better control over quality than with either stationary compactors or dumpsters.

An analysis of the expected cost of collection using rear loading packers and various assumptions was made. The results are presented in Table 2.5 a & b. The cost per kilogram is far higher than for the case of the flatbed truck discussed above. At least two loads per day would be required to make the collection economical. This is because of the expected low load weights achievable per trip, combined with the relatively high cost of the vehicle, driver and loader.

Such a collection would probably not average better than one stop every ten minutes, and to achieve this, pick ups would need to be relatively close together, have good access for quick entry and exit, and have the plastic set out and ready for loading in the loading area. On this basis, an average amount of about 150 kilograms per stop would be required to achieve economic collection costs. This establishes a benchmark for screening potential plastic generators by quantity generated.

In practice, every stop will be different in terms of quantity, resin type, purity, degree of mixing, and time taken to get to the stop and load. A relatively small generator with 'good' material en route may be worth stopping for while a larger generator with relatively poor material may not be worth collecting from simply because he is off the beaten track.

A small quantity generator could be attractive as a source of material if he were prepared and able to accumulate plastic to this minimum quantity for collection. In that case, the constraint would be on storage space available, and the proximity to other sources that are able to be collected on the same schedule.

From this analysis, it seems clear that it will not be feasible to offer small quantity generators any payment for material collected. The threshold for payment for collected material would have to be in excess of 1000kg. per pick up. In addition to collection expense, introducing payment for material received would require the weighing of material and the establishment of a recording and payment system which would add further to the cost of obtaining the material.

Table 2.5a
Rear Loading Packer
Collection Analysis

Packer Truck and Crew

Cost per year	$160,000
Cost per day	$640/day

Daily Productivity Versus Cost

		Cost of Collection		
		Per Tonne	Per Kg.	Per Pound
One Load Per Day	2.0 T/load	$320	$0.320	$0.145
	2.5 T/load	$256	$0.256	$0.116
	3.0 T/load	$213	$0.213	$0.097
Two Loads Per Day	2.0 T/load	$160	$0.160	$0.073
	2.5 T/load	$128	$0.128	$0.058
	3.0 T/load	$107	$0.107	$0.048

Table 2.5b
Rear Loading Packer
Loading Time And Weight Per Stop

Available Loading Time

Loads Per Day	One	Two
Daily productive time	450 minutes	450 minutes
Travel/unloading time	50 minutes	100 minutes
Net route and loading time	400 minutes	350 minutes

Average Weight Per Stop

	Time Per Stop	5 minutes		7.5 minutes		10 minutes		15 minutes	
	One Load	80 stops		53 stops		40 stops		26 stops	
	Two Loads	70 stops		46 stops		35 stops		23 stops	
Loads Per Day	Tonnes Per Day	Weight Per Stop							
		Kg.	lbs.	Kg.	lbs.	Kg.	lbs.	Kg.	lbs.
1	2.0 T/day	25	55	38	83	50	110	77	169
1	2.5 T/day	31	69	47	104	63	138	96	212
1	3.0 T/day	38	83	57	125	75	165	115	254
2	4.0 T/day	57	126	87	191	114	251	174	383
2	5.0 T/day	71	157	109	239	143	314	217	478
2	6.0 T/day	86	189	130	287	171	377	261	574

Shaded area deemed unfeasible due to cost, rate of pickup

Table 3.1
Manufacturing and Processing Equipment

	Number	Value
Forklift	1	$25,000
Bobcat	1	$25,000
Extruder	1	$350,000
Granulator	1	$60,000
Densifier	1	$19,500
Shredder	1	$4,650
Chiller	1	$15,000
Compressor	1	$10,000
Pallet Truck	1	$375
Air Conveyors (Gran)	2	$3,000
Air Conveyors (Mix)	1	$1,500
Air Lines		$4,500
Electrics		$30,000
Silos	3	$13,500
Mixer	1	$12,000
Electrical Spares		$5,000
Mechanical Spares		$10,000
Moulds	24	$12,500
Strapping Machine -	1	$1,500
Racking		$7,500
Cooling Dollies	2	$1,200
Value Added Shop Tools		$40,000
Tool Kits		$9,000
		$660,725

3.0 OVERVIEW OF THE ESTABLISHMENT AND OPERATION OF A MIXED PLASTICS RECYCLING FACILITY

3.1 Building and Equipment Requirements

The operation of a mixed plastics recycling facility involves several steps:

- receiving and sorting incoming plastics
- granulating plastic
- densifying of film plastic
- mixing and blending plastic feed
- extruding the mix of plastics
- making value added products (optional)
- warehousing and distribution

The size of plant required to provide sufficient space for these activities would be a minimum of 8000 ft^2. A summary of equipment required and costs is provided in Table 3.1. The operations performed at the facility are described briefly below.

3.2 Operations

Incoming plastic will be received by a receiver and sorters. It is expected that two man hours would be required per metric tonne (1100 lbs./hour) of material received for receiving and rough sorting.

Granulating equipment can supply feed for more than three machines and densifying equipment can supply feed for up to three machines. Densifying is required for film plastics only, which are expected to provide about 30% of the raw material feed. All transport of granulated plastics and feed to mixers will be by air conveyors.

The throughput of the recycling machines is rated at 440 lbs. per hour. Each machine requires a dedicated operator. However the machines are largely automatic, permitting the operators sufficient time to rack and move their own production into storage.

Additional operating staff include a storeman/shipper, foremen for day shift operations, and a plant supervisor.

The development of value added products from the basic product is seen to provide an increased source of income and expanded opportunities for the sale and use of recycled plastic. For this reason, it is expected that a range of value added products will be developed and marketed.

Thus far, the product range to be produced in this workshop has not be detailed. The amount of labour, equipment and productivity remains to be defined. The types of processes include:

- special colour finishes, including reflective finishes for signs and markers
- shaping by turning, sawing, routing
- assembly of kits or finished products

The labour required would consist of a relatively skilled tradesman with wood working capabilities and a number of general labourers to assist. The product is worked with conventional wood working tools.

4.0 FACILITY OPERATING COSTS

The cost of raw material that is acceptable to the process is not easily established as there is no clearly established market value for the material or products produced. Some indications are available based upon the expected manufacturing costs.

An analysis of the costs of manufacture is shown in Table 4.1. Based on a material cost of 11 cents per kilogram (5 cents per pound), the cost of the waste plastic represents 23% of the expected variable cost of manufacturing. The only larger variable cost is labour, at 26%.

In addition to the variable costs, fixed manufacturing costs, primarily equipment depreciation and rent, will range from 26 cents to 77 cents per kilogram (12 cents to 35 cents per pound), depending upon the number of shifts that the equipment is kept running. This will be driven primarily by the amount of manufactured product that can be sold.

Fixed manufacturing costs would be somewhat lower for a processing plant with multiple extruders as rental costs, storage areas, and some other equipment costs do not increase proportionately with each additional machine.

In addition to the manufacturing overheads, there are also general administrative and sales overheads. These are even more sensitive to the scale of operation, being relatively constant until quite large volumes of production are reached from three or more machines.

An ex factory price for the basic product is expected to be between 88 cents and $1.10 per kilogram (40 cents to 50 cents per pound). On this basis, the finished product price would rise by 5% to 6.5% for a 50% rise in raw material price above the assumed 11 cents per kilogram. What is not clear is how price sensitive the proposed product markets will be. Already, the product would be at a substantially higher price compared to pressure treated pine, or other materials with which it most likely will be competing.

Table 4.1
Production Cost Analysis

Variable Costs, Basic Product	Cents per kg.	Cents per lb.	Percent
Waste Plastic Materials	11.0	5.0	23%
Labour	12.1	5.5	26%
Other Materials	8.8	4.0	19%
Utilities, Maintenance	4.4	2.0	9%
Sales Commissions	5.5	2.5	12%
Royalties	5.5	2.5	12%
Total	47.3	21.5	

Fixed Manufacturing Costs	Cents per kg.	Cents per lb.
One shift per machine	77.0	35.0
Two shifts per machine	39.6	18.0
Three shifts per machine	26.4	12.0

For this reason, a target average cost of raw materials of 11 cents per kilogram has been set. (5 cents per pound). While some material may be obtained for less, there would be provision to acquire some material of higher quality at a higher price to ensure the appropriate balance of resin types.

5.0 SUMMARY AND CONCLUSIONS

The supply survey has confirmed the findings of previous studies that large quantities of plastic waste are being recycled, and have been for many years.

The supply survey has established the existence of large quantities of plastic waste which are currently not being recycled. This material is generally unattractive to the plastic regrind industry because it consists of mixtures of resins or is contaminated. A large portion of this material is acceptable to the proposed process.

Based upon the relatively small portion of all generators of plastic waste contacted, it is evident that there is enough available waste plastic from commercial and industrial sources to meet the requirements of several mixed waste plastic recycling machines.

The expected constraints on the price of the finished product require that the cost of the raw materials be kept as low as possible, even though these cost represent only about 10% to 12% of the finished product price.

An analysis of the cost of obtaining this material clearly shows that supply from large sources is economical at the target cost of 11 cents per kilogram (5 cents per pound). The collection of plastic from sources supplying less than 150 kilograms per stop is questionable due to the increasing costs of collection as the quantity per stop reduces.

Given the cost of collection, it will not be economical to offer any but the largest generators any remuneration for material collected. Based upon comments received during the survey, there should be sufficient material available from sources that are prepared to accept free removal as sufficient incentive to handle and accumulate plastic wastes separately to supply the proposed plant.

The best way to ensure the continued cooperation of such sources is the maintenance of high tipping fees at waste management facilities. Should these fees drop substantially, the generators would have to be paid for waste plastic, making the recycled plastic product more expensive. An alternative would be to ban these materials from disposal facilities as it has been done with corrugated cardboard.

v4:c:proposal\suppsurv